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Case Study

Aerial Mapping: Photogrammetry with the help of **microdrones md4-1000**
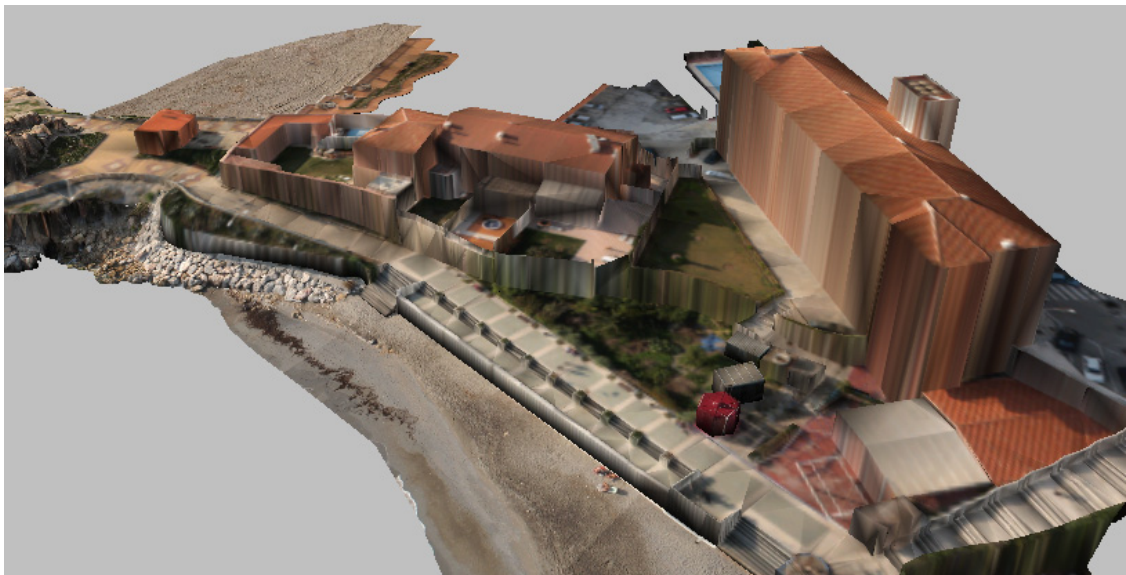
Profiles: microdrones / CARTO UAV

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Case Study for
Aerial Mapping: Photogrammetry with the help of microdrones md4-1000

What can be done?

In short, anything that can be done by classic photogrammetry can be done by UAV borne cameras, the limitation being only on the part of the UAV (max. flight height and battery lifetime) not on the method. The flight height limits in practice the scale for which the UAV is an alternative. Small scale works can be done at lower cost by an airplane flying at high altitude and covering the whole area with much less photographs than the UAV would need.

On the other end, UAVs can operate at small heights not allowed for planes, e.g. 80m. This introduces UAVs in the field of topography, actually achieving topographic precisions. UAVs are ideal for urban areas, medium or large sized rural works or places with difficult access. It requires shorter times to complete the work than topographic methods, hence providing a more economical alternative.

What cameras can be used?

Sony -NEX7.
A compact camera with interchangeable objectives

Cameras with interchangeable objectives are to be preferred, so that the lenses are fixed and do not expand or recede when the camera is turned on and off. The large distortions of com-pact cameras (as compared to metric cameras) is not a problem, for it is an error that remains constant and can therefore be calibrated and analytically eliminated by the soft-ware. Subpixel precision is achieved once the distortion is taken into account. **Non-metric cameras MUST be calibrated** in order to be used for photogrammetric purposes.

The workflow

The flow of work proceeds as in classic photogrammetry. The entry point is the required precision. This value determines the ground pixel size (a given altimetric precision requirement amounts to a planimetric requirement of half the value). The pixel size in turn determines the flight height, as H=sz*f, where sz is the ground pixel size and f the focal length expressed in pixels. A flight height below that value is permitted, a height above it not.

Once the flight height has been determined the flight is designed with the help of some utilities, such as mdCockpit. The overlapping along the flight direction and between adjacent flight lines may be of 66% and 20% for instance.

The taken photographs, the camera calibration and several control points is all that is needed to obtain the different products.

mdCockpit.
Software for UAV route planning
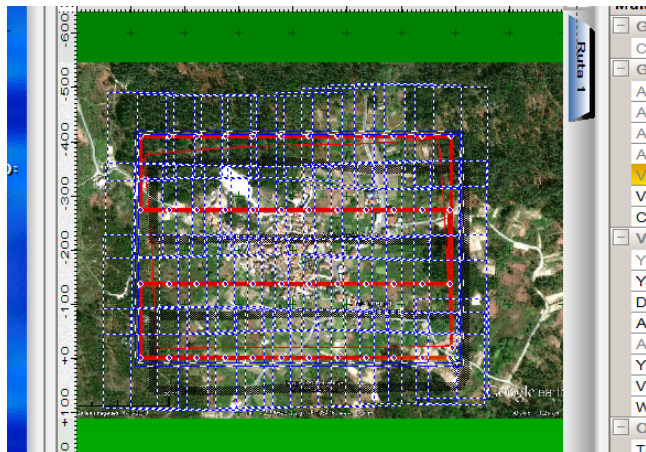
Results and Products
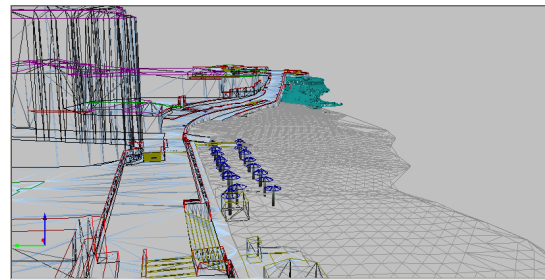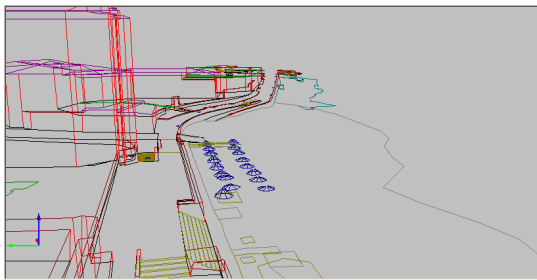
- A card file with restituted featured
- A DTM, automatically generated and/or based upon break lines
- Contour lines
- An orthophotography

Technical Background Information

The resolution in height, or altimetric pixel (AP), is the difference in height of the intersection of two homologous rays from adjacent photographs when one of the two rays is moved by one pixel along the line joining the two projection centers (typically this is the photograph x direction).
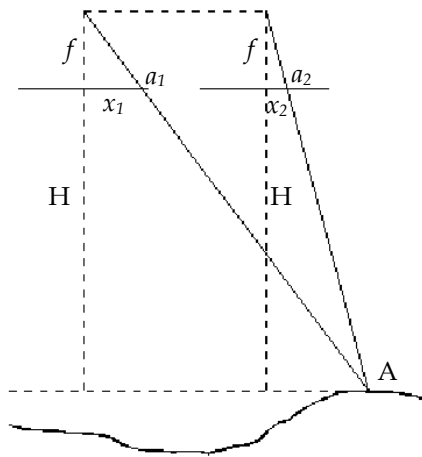
B, *Base*: Distance between two consecutive proj. centres.

H: Flight height

$p, parallax = x_1 - x_2 = f\,B/H$

A small change in Z of A makes the parallax change by

$$\Delta p = f/H\,B/H\,\Delta Z$$

An so corresponding to $\Delta p = 1$ px, ΔZ is

$$\Delta Z = H/f\,H/B$$

Since H/f is the planimetric pixel size, the AP is the same multiplied by the ratio H/B, which in turn equals f/p. The parallax is the amount by which each photo-graph advances with respect to the previous one. Thus, if the image side along the flight directions has a length of 4000 px and the overlapping between consecutive photographs if of 66%, the parallax will equal 4000• 0.34 = 1360 px.

For this reason the AP is smaller, and hence the altimetric resolution better, if the flight direction follows the longer side of the images, but cameras are often mounted the other way.

Here are the values for a 6000 x 4000 px2 camera with a focal length of 16mm, equivalent to 4000px. The area covered by each model has been computed based on an overlapping of 66%, 20% for the short case and 64%, 25% for the long one.

Flight Height	Ground Pixel Size	AP (short)	AP (long)	Ha / model	models / Ha
50 m	1.25 cm	3.7 cm	2.3 cm	0.10	9.8
60 m	1.5 cm	4.4 cm	2.8 cm	0.15	6.82
80 m	2 cm	5.9 cm	3.7 cm	0.26	3.83
100 m	2.5 cm	7.4 cm	4.6 cm	0.41	2.45
120 m	3 cm	8.8 cm	5.6 cm	0.59	1.70
140 m	3.5 cm	10.3 cm	6.5 cm	0.80	1.25
160 m	4 cm	12 cm	7.4 cm	1.04	0.96
200 m	5 cm	15 cm	9.3 cm	1.63	0.61
240 m	6 cm	18 cm	11 cm	2.35	0.43
300 m	7.5 cm	22 cm	14 cm	3.67	0.27
400 m	10 cm	29 cm	19 cm	6.53	0.153

An Example Flight

The Area

In this work it was required to obtain a 3D model of three shaving mounds. Three possible methods are to be considered:

Classical surveying: This is not possible because the mounds cannot be walked up (a person would sink in it). Besides, it is an area of restricted access that cannot be occupied for a long time by persons.

Terrestrial laser scanner: There are many obstacles creating blind areas. Too many stations would be required and the amount of time needed to complete the observations (and hence the amount of time occupying the area of restricted access) and subsequent work would be excessive. It is not impossible, but if other method can be found it is to be preferred.

Low height photogrammetry with a microdrone: The area to be covered is small. A microdrone flight above it would require little time. The area only has to be occupied for a short time in order to measure a few control points. The office work is light too, just drawing the lines defining the mounds shape. Thence the model is formed and the volumes computed by any software tool able to do so.

On the other end, UAVs can operate at small heights not allowed for planes, e.g. 80m. This introduces UAVs in the field of topography, actually achieving topographic precisions. UAVs are ideal for urban areas, medium or large sized rural works or places with difficult access. It requires shorter times to complete the work than topographic methods, hence providing a more economical alternative.

Here is an overview of the area:

The Flight

A flight 100m above the object was enough for the required precisions. The ground pixel size is 2.5 cm and the AP 7.5 cm (the camera was mounted in the "short" position).

Two strips were necessary. The flight was programmed with mdCockpit.
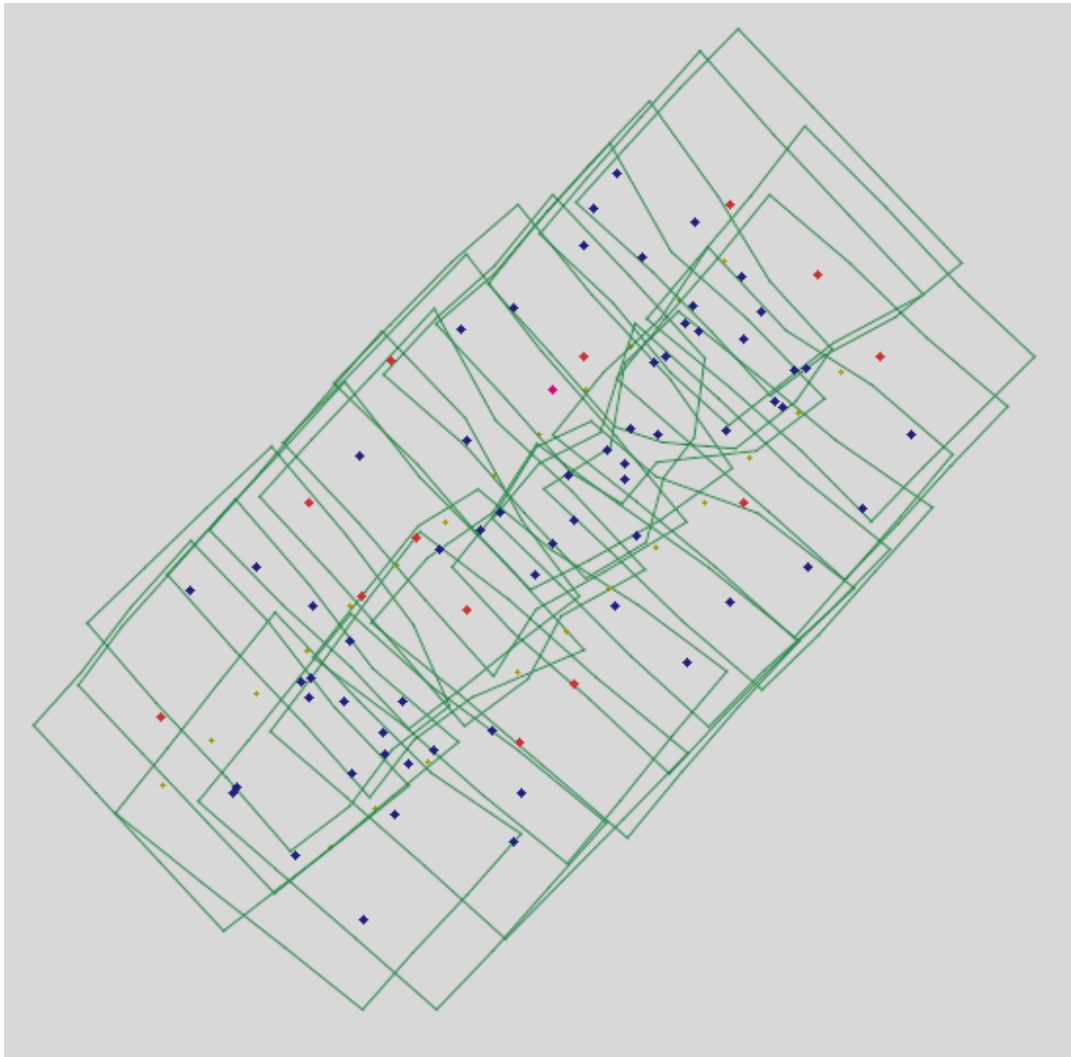
There are 24 photographs. The red points are the control points. These and the blue one are the points measured for the computation of the aerial triangulation. Many programs offer the possibility to automatically select points and match them along the different photographs where they appear. In this work, due to the characteristics of the object an automatic process was likely to make many mistakes; it is therefore that a manual measuring was preferred.

The creation of the 3D model

The lines defining the model for each of the three mounds were drawn. This process of drawing 3D elements based on the photographs is called restitution. At each moment the operator is working with a pair of photographs, which enables the measuring and drawing in 3D.
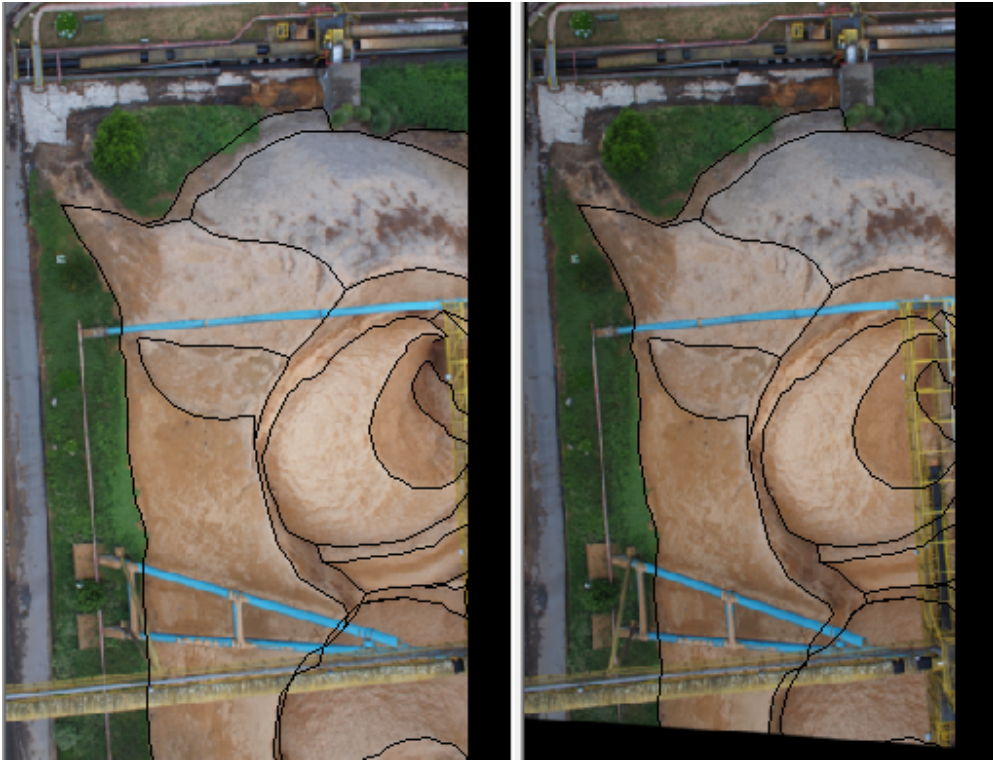
Here is a perspective view of the whole complex of lines and the model derived thereof.
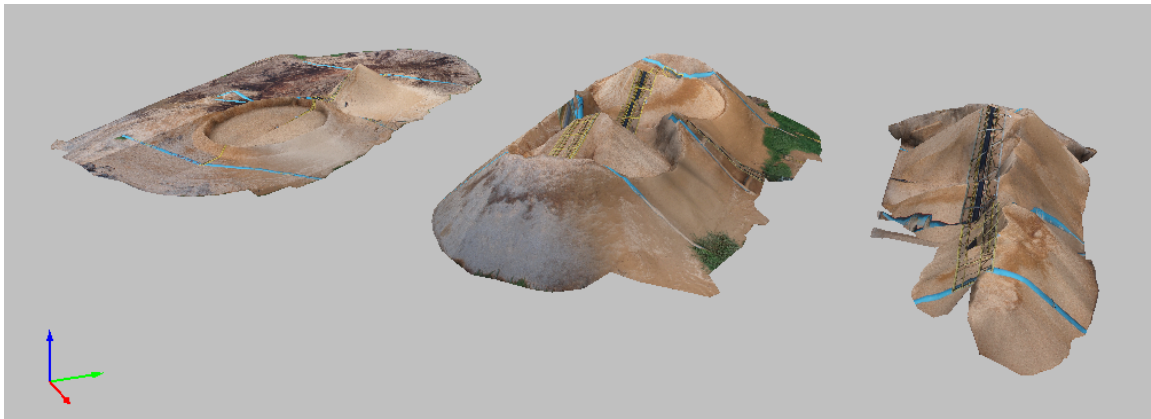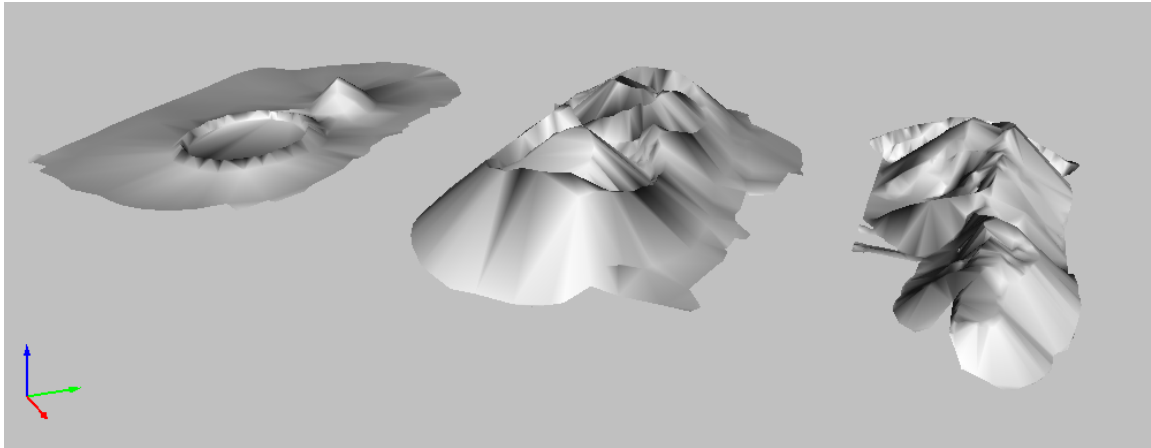
Based on this model the needed volumes were computed. An orthophotograph was neither needed nor interesting for this work.

A Mixed Urban-Coastline Area

Urban areas are ideal for microdrone UAVS. A short flight above the streets can save many ours of ground surveying work disturbed by people, cars, walls blocking the view, etc.

The urban area is restituted as described in the previous example: the lines of sharp objects are drawn (the pavement, buildings, walls, steps ...) and a model is formed based exclusively on those lines. On the contrary, rural open areas or, as in this case, beach and rocks are modeled by the software by automatic correlation of the photographs. This can be appreciated in the triangular network showed here. Note the regular pattern on the sand obtained by the software by automatic correlation. Note also the superposition of volumes and the detail in the drawing in the urban part. Each individual step has been restituted in 3D, and there were more than one hundred in the area. Just figure how long it would take to measure all these by classic surveying
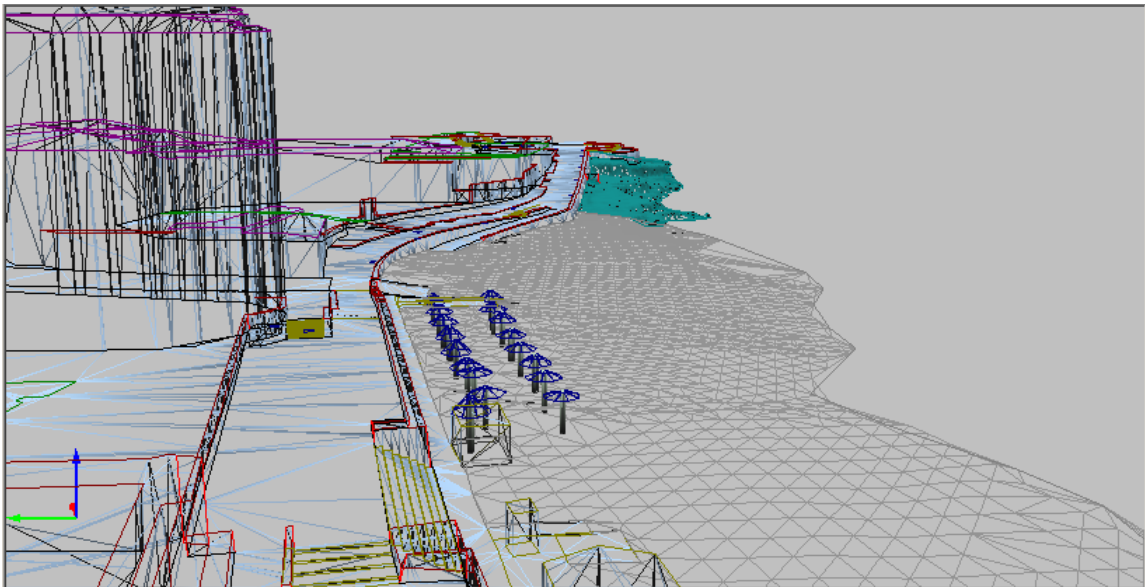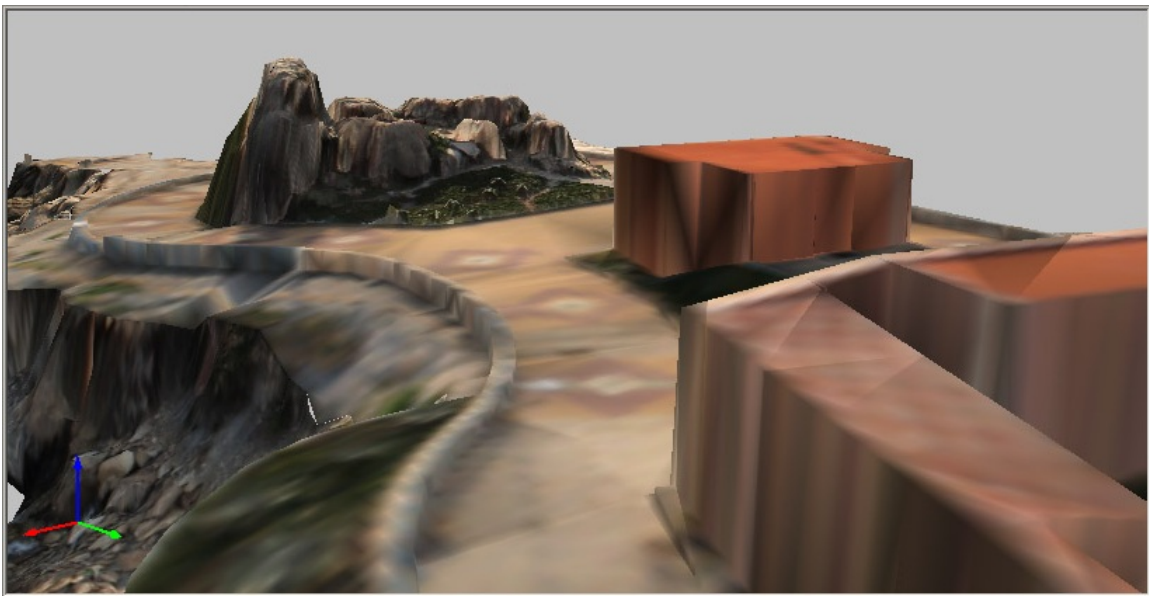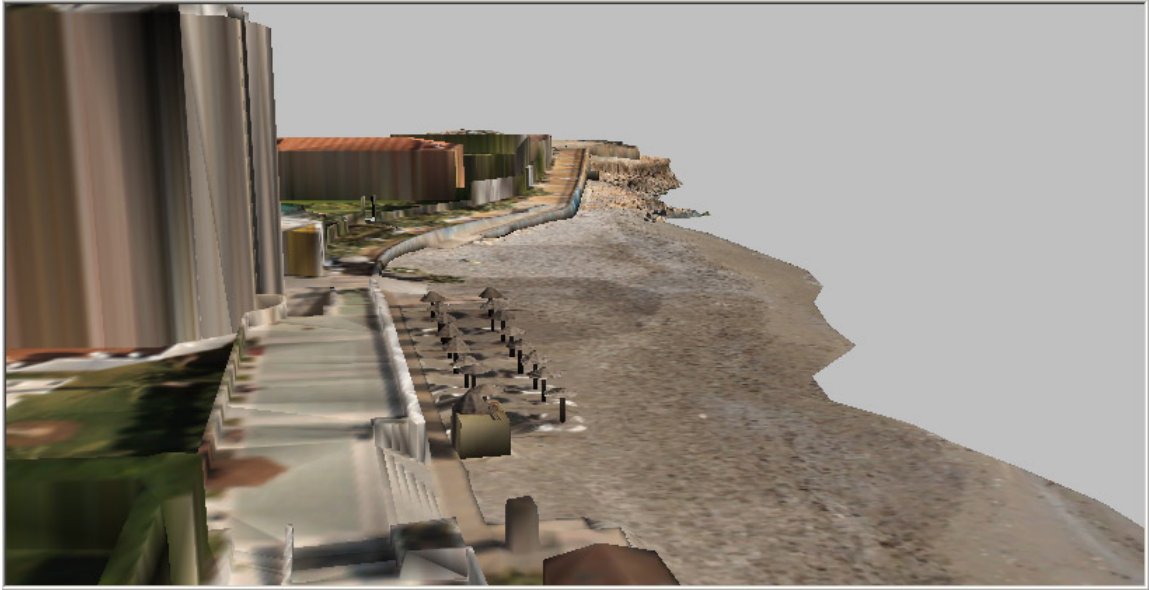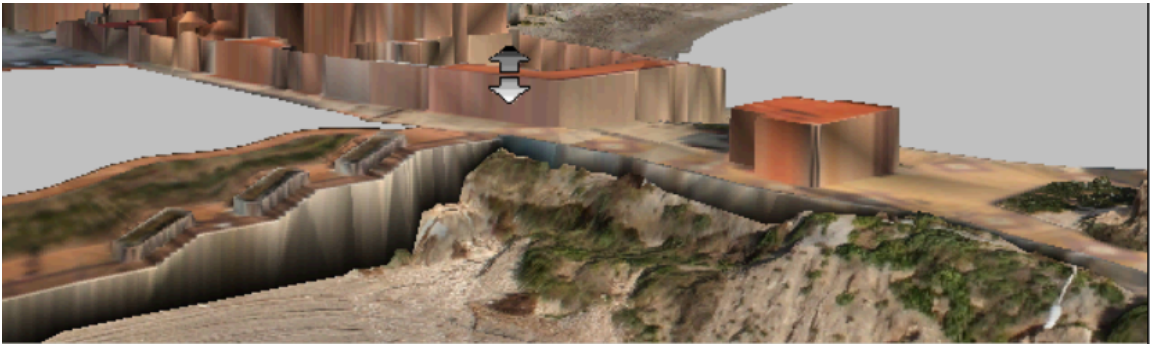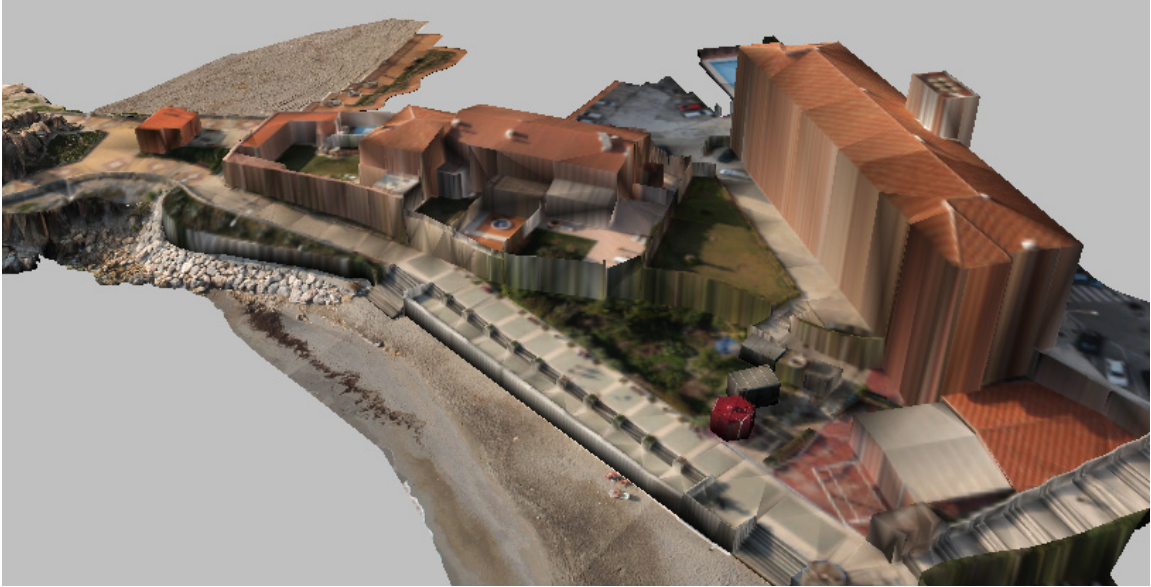
Used Products

- **md4-1000 – Short Overview**
    - Payload up to 1200g
    - Flight time up to 88min
    - Low-noise motor operation
    - Weather resistant carbon fiber body
    - Automatic or manual mode – selectable

- **Equipment / Camera**
    - Sony Nex7

- **Software**
    - mdCockpit GPS Waypoint
    - GIS Software - CARTOUAV